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Treating root-surface caries

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Gingival recession associated with aging and periodontal therapy exposes root surfaces, which are then susceptible to root caries. Resin-modified glass ionomer, glass ionomer, compomer, composite resin, and amalgam restorative materials are frequently used to restore carious root lesions. Amalgam continues to be used successfully to restore root caries. Resin composites, compomers, glass ionomers, and resin-modified glass ionomers are increasing in popularity because they are aesthetic and bond to tooth structure. Unfortunately, only modest evidence from controlled clinical trials is available to support the use of any of these materials for high caies—risk patients. Recurrent caries receives little attention from investigators of clinical trials, who normally select low caries—risk patients in whom to place restorations. In the most recent meeting of the International Association for Dental Research, out of 2167 abstracts only one paper was presented that summarized the results of a clinical trial evaluating recurrent caries associated with restorative materials in high caries—risk patients. [1] This lack of data makes specific material recommendations for the restoration of root-surface caries difficult, although some data are appearing. Recent evidence demonstrates that fluoride-releasing materials inhibit recurrent caries in restored root surfaces. Although fluoride supplements reduce caries in high-risk patients, the effects seen from these materials are related to the fluoride released. Fluoride-containing solutions have a dose-response relationship to caries. The higher the fluoride in the solution or released from a restoration, the greater the protection. Fluoride gels, delivered in trays, bathe the tooth with significantly greater amounts of fluoride compared with the amounts of fluoride released from restorative materials. The percent of caries reduction when gels are used is therefore greater.

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This article summarizes the effectiveness of restorative materials used to restore root surfaces, the mechanisms by which these materials reduce caries, and placement techniques for restoring root-surface lesions. Patients are classified into low, medium, and high caries risk groups for root caries, and material recommendations are made for each category. Effective plaque control, xylitol-containing chewing gums, antimicrobial agents, fluoride-releasing restorative materials, topically applied fluoride, and fluoride-containing toothpastes provide maximum protection for the high caries risk patient.

Incidence of root caries

An NIDR oral health survey [2] and a study by Ripa [3] reported an increasing incidence of root caries in adults residing in the United States. Comparison between the youngest and the oldest age groups in this survey showed that the oldest group had a 2.4 times increase in coronal caries, but a 21.8-fold increase in root caries. With increasing age, root surfaces are exposed to the oral environment, predisposing teeth to root-surface caries or cervical erosion lesions. [4] With a dentate, aging population in the United States, the numbers of root caries lesions in this population have multiplied. [5] Not only are primary root lesions frequently found in the elderly but secondary caries also are found at restoration margins on dentin or cementum in areas in which access is difficult, adequate isolation is impossible, and complete caries removal is also difficult. It is not surprising that recurrent caries is a significant problem around root-surface restorations. [6]

Etiology and carious process

The triad of susceptible root surface, bacteria, and a fermentable carbohydrate provides the necessary ingredients for root caries. The bacteria associated with root-surface lesions have been reviewed by Zambon and Kasprzak, [7] and a strong clinical association between *Streptococcus mutans*, *Lactobacillus,* and root caries has been established. In the same article, *Actinomyces* was not clearly implicated in root caries formation. Demineralization results from acid secretion of *Streptococcus mutans* and *Lactobacillus* on the tooth after eating a diet high in fermentable carbohydrates. [8] The acids produced from the bacteria during this process diffuse within the plaque to the cementum or dentin, covering the root surface, and slowly dissolve the root surface. The tooth reacts to this invasion by forming sclerotic hypermineralized dentin to slow the process of the bacteria toward the pulp. Demineralization begins at a certain pH level called the *critical pH.* Root caries begins at a higher pH than enamel. The critical pH for demineralization of enamel is 5.5 and for dentin is 6.2 to 6.4. [8] Demineralization is approximately twice as rapid on root surface as on enamel because the root has half as much mineral as enamel and demineralization occurs at a higher pH. As demineralization proceeds, mineral is lost, exposing collagen. Enzymes generated by bacterial plaque [8] degrade the collagen, forming a cavitated lesion. Active lesions are rapidly progressing and tend to be brown or yellow (Fig. 1); inactive lesions progress slowly, if at all, and are darker (Fig. 2). Darker lesions are often associated with *Lactobacillus*. Remineralization occurs during periods of neutral pH and replaces calcium and phosphate removed during demineralization, when the pH drops below the critical pH. Caries disrupts the demineralization and remineralization balance by increasing demineralization.

Fig. 1. Typical rapidly progressing caries.

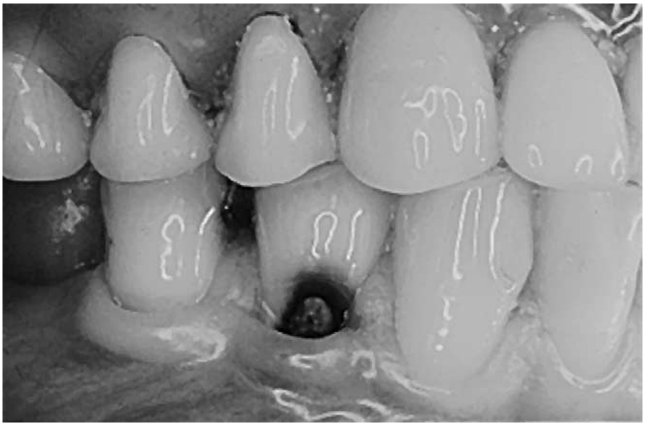

Fig. 2. Slowly progressing arrested root caries.

Factors controlling root caries

Reducing caries by plaque removal and reducing sucrose intake, especially limiting sucrose-containing soft drinks, are effective methods to control root caries. Patients with salivary gland dysfunction, leading to reduced salivary output, have increased susceptibility to root caries because the buffering effects of the saliva and the mineral available for remineralization are missing. Although it is not known how much saliva is necessary to protect teeth from caries, conditions producing reduced saliva, Sjogren's syndrome, or head and neck radiation lead to rapidly progressing caries (Fig. 3). Healthy, unmedicated patients have salivary flow rates that do not decline with age; comparisons [9] with healthy subjects of the same age show that dry mouth is produced by medications. Many sedatives, antidepressants, antihistamines, and antireflux medications have anticholinergic effects and reduce salivary flow. More than 400 medications [10] are associated with xerostomia.

Materials used to restore root lesions

Many materials have been used to restore root-surface caries. These materials are classified and compared in Table 1. Recent evidence supports fluoride-releasing materials for the restoration of these defects.

Silver amalgam

Although safety and disposal concerns have been raised, amalgam has been a mainstay in restorative dentistry for more than 150 years. [11]

Fig. 3. Lingual view of the Mandibular incisors showing rapidly progressing caries in salivary deficient subject who had head and neck radiation therapy.

Table 1
Fluoride-releasing materials classified

Material	Use	Classification	Manufacturer	Setting mechanism	Fluoride release	Fluoride recharge
Ketac-Fil	Restorative	Conventional glass ionomer	3M ESPE, Norristown, PA	Acid-base	High	High
Fuji II	Restorative	Conventional glass ionomer	GC, Chicago, IL	Acid-base	High	High
Ketac-Silver	Restorative	Conventional glass ionomer	3M ESPE, Norristown, PA	Acid-base	Medium	Medium
Miracle Mix	Restorative	Conventional glass ionomer	GC, Chicago, IL	Acid-base	Highest	High
Fuji II LC	Restorative, core material	Resin-modified glass ionomer	GC, Chicago, IL	Tri-cure (acid-base cure plus light and chemical resin)	High	High
Fuji IX	Restorative	Densified glass ionomer	GC, Chicago, IL	Acid-base cure	High	High
Ketac-Molar	Restorative	Densified glass ionomer	3M ESPE, St. Paul, MN	Acid-base cure	Medium	High
Vitremer	Restorative, core material	Resin-modified glass ionomer	3M ESPE, St. Paul, MN	Tri-cure (acid-base plus light and chemical resin cure)	High	High
Photac-Fil	Restorative	Resin-modified glass ionomer	3M ESPE, St. Paul, MN	Tri-cure (weak acid-base plus light and chemical and resin cure)	High	High
Geristore	Restorative, luting agent	Composite resin	Den-Mat, Santa Clara, CA	Dual cure (light and resin chemical cure)	Low	Low
F 2000	Restorative	Compomer	3M ESPE, St. Paul, MN	Light cure of resin primarily, acid base	Medium	Moderate
Dyract AP	Restorative material	Compomer	LD Caulk, Milford, DE	Light cure of resin primarily, acid base	Medium	Moderate
Compoglass F	Restorative material	Compomer	Ivoclar, North America	Light cure of resin primarily, acid base	Medium	Moderate
Heliomolar	Restorative material	Composite resin	Ivoclar, North America	Light cure	Low	Low
Tetric Ceram	Restorative material	Composite resin	Ivoclar, North America	Light cure	Low	Low
Solitaire 2	Restorative material	Composite resin	Kulzer, South Bend, IN	Light cure	Low	Low
SureFil	Restorative material	Composite resin	LD Caulk, Milford, DE	Light cure	Low	Low

Amalgam restorations have advantages compared with other restorative materials: amalgam is technique insensitive, the margins are self-sealing, and it has good wear resistance. Amalgam is far from ideal, however, because of its silver color, lack of adhesion, poor to no fluoride release, and concerns about the disposal and safety of its mercury component. Modern dental amalgam is an alloy of silver, tin, copper, and zinc mixed with mercury. High-copper amalgams have improved clinical performance compared with low-copper (gamma 2-containing) alloys. High-copper, zinc-containing amalgams have less marginal breakdown and increased longevity compared with non-zinc-containing amalgams. [12,13] One fluoride-releasing amalgam has been developed; however, the amount of fluoride released from this amalgam was small and the release was of short duration. Consequently, fluoride-releasing amalgams are not used in the United States. [14] Because of the growing concern about the safety of mercury-containing amalgam, silver-containing restorative materials with reduced or no mercury content have been developed but have not captured a significant market share, partly because of the declining sales of amalgam in the United States.

The marginal seal at the amalgam-tooth interface depends on the setting contraction and corrosion of the amalgam. High-copper amalgams have increased expansion, lower creep, and lower compressive strength when water contaminates the amalgam during condensation. [15] High-copper alloys leak more initially than previous alloys because they corrode less than gamma 2-containing alloys. High-copper alloys contract during the first 24 hours after placement and slowly expand for 6 months, when they become dimensionally stable. [15] When the dimensional stability of Tytin, Dispersalloy, and Zenith was measured for 2 years, Tytin had the least expansion and often a slight contraction. This may explain clinical reports of postoperative thermal sensitivity with Tytin.

Amalgam bonding agents have been used in several clinical trials, and their long-term effectiveness has been demonstrated clearly in two 5-year clinical evaluations [16,17] comparing large cuspal-coverage amalgam restorations to pin-retained amalgams. Benefits with bonded amalgam restorations include bonding to weakened tooth structure, thereby improving remaining tooth strength, [18] and preservation of tooth structure [19] with modified cavity preparations. AmalgamBond is by far the most successful amalgam bonding agent used today with clinical and laboratory testing to support its use. Because isolation and hemorrhage control are difficult during the restoration of carious root lesions, adhesives may not be successful owing to contamination of the bonding agents.

Composite resin as a root-surface restorative material

Microfilled composite resins often are advocated for restoration of root-surface lesions because they have lower modulus than hybrid composite resin. The argument for this type of composite resin restoration is that because the tooth flexes during mastication, flexible restorative materials flex with the teeth. Little clinical documentation has been located to justify this claim, however. Composite resin restorative materials are aesthetic, generally light cured, and bond to tooth structure by coupling with dentin bonding agents. The greatest single problem with resin materials is polymerization shrinkage, which creates stress at the marginal areas, bends the tooth, opens margins, or cracks enamel. Bond strengths exceeding 20 MPa eliminate gap formation produced during polymerization shrinkage. [20] Although improvements in bonding agent efficiency increased in early generations of bonding agents, no significant improvement in bond strengths has been seen with single-application primer/adhesive materials (fifth-generation bonding agent) and the no-etch, no-rinse bonding materials (sixth-generation bonding agents). In fact, bond strengths have decreased with these newer-generation materials. Because sixth-generation materials do not etch and rinse away any contaminated smear layer, this group of adhesives is particularly sensitive to contamination. [21]

Fluoride-releasing composite resins

These resins release fluoride from the filler particle, the radiopaquing agent, or the resin matrix. These materials release little long-term fluoride, and unlike resin-modified glass ionomers and compomers, have little ability to recharge and release fluoride from topically applied fluoride solutions or from fluoride-containing toothpaste. Although studies [22,23] have reported that fluoride-releasing resin can inhibit in-vitro enamel caries at the restorative margins, caries inhibition by fluoride-releasing materials on cementum or dentin root surfaces produces inconsistent results. [24] This finding is attributable to the higher fluoride concentrations needed to remineralize root surfaces compared with enamel surfaces and the decreased amount of fluoride released from composite resin compared with glass ionomer. Because composite resins are more wear resistant than glass ionomers or compomers, composite materials are reserved for occlusal load-bearing areas. Fluoride-releasing composite resins, with their low fluoride release and no recharge, are generally not used on root surfaces in high caries risk patients.

Conventional and resin-modified glass ionomer restorative materials

Conventional glass ionomer restoratives, introduced in the early 1970s, [25] are not widely used in the United States because handling, placement, and finishing are difficult. [26] Water contamination during placement produces a weak, opaque restoration, while dehydrating glass ionomers cause cracking of the restoration. To prevent drying during finishing, an unfilled resin or varnish is applied to the finishing disk and to the restoration's surface. If a restoration is finished dry, or if the restoration is isolated, cracking may occur months after its initial placement. All glass ionomer restorative materials contain water and are supplied as a powder and liquid. These materials bond best to moist tooth structures, and drying reduces bond strength and increases leakage significantly. Even with these limitations, properly placed glass ionomer restorations are durable and clinically successful. Matis et al. [27] have reported an 80% 10-year retention rate with Ketac-Fil, a conventional glass ionomer. Conventional and resin-modified glass ionomers have similar setting reactions. [28] Both begin with an acid-base reaction that releases fluoride as a byproduct of the setting reaction. As the glass ionomer matures, it gains increased translucency and strength. A common tendency for clinicians inexperienced with glass ionomers is overfinishing the marginal areas. Because glass ionomers develop strength slowly, they should be finished with light pressure and less abrasive disks. Resin-modified glass ionomers have a second setting reaction due to a free radical polymerization initiated by light curing. Light curing gives the resin-modified glass ionomer high early strength and allows easier finishing and polishing. Manufacturers recommend placing a varnish or unfilled resin over the finished restoration; unfortunately, this coating reduces fluoride release into the prepared tooth and into the surrounding tooth. [29,30] Bonding agents placed on prepared tooth surfaces reduce fluoride movement from the restoration to the tooth; however, the light-cured primer, used with Vitremer, does not inhibit fluoride movement out of the restoration and still allows fluoride uptake into cut dentin.

Two clinical trials have shown a 30% reduction in recurrent caries around glass ionomer restorations in high caries risk patients. [1,31] Clearly, these materials are the materials of choice in high caries—risk patients. Wood et al. [32] placed 54 pairs of class V Ketac-Fil and amalgam restorations in a clinical trial in xerostomic patients who received head and neck radiation. If an acidic topical fluoride solution was used, the acidity eroded the glass ionomer restorations. When the topical fluoride was not used, the glass ionomer restorations had longer survival time than the amalgam restorations. This study revealed two important points: that erosion of glass ionomers by acidic fluoride solutions was profound, and that neutral fluoride solutions should be used nightly.

Compomers

Compomers are the newest group of fluoride-releasing materials. These non-water-containing, single-component, light-cured materials are similar to composite resin in their handling, bonding, and finishing. Although the retention rates of these materials in cervical erosion lesions are good, little clinical data exist for any reduction in recurrent caries associated with these materials. Because their fluoride release and recharge rates are significantly lower than glass ionomers, and because compomers are unproven for the treatment of high caries risk patients, the recommended material of choice for root-surface lesions remains the resin-modified glass ionomer.

Fluoride release and recharge

Many studies have confirmed that fluoride is released from fluoride-releasing restorative materials [33–35] and that the high initial release rapidly declines to a low long-term release (Fig. 4). Fluoride released from glass ionomer restorations has been collected in whole saliva in vivo. [36] The fluoride released from glass ionomer and silicate cement is incorporated into tooth structure. [37–39]

Glass ionomer restorative materials are fluoride reservoirs. Toothpaste with fluoride, topical fluoride solutions, and fluoride rinses recharge fluoride depleted from glass ionomer restorations (Fig. 5). [30] Recharge does not decrease with time, and different fluoride-containing agents may be used to increase the recharge. Aged glass ionomer specimens, recharged with a fluoride-containing toothpaste, a neutral sodium fluoride solution, or a combination of the two produce increased fluoride release compared with levels before the recharge. Again, the higher the fluoride applied in the external solutions, the greater the recharge. Restorations exposed to multiple sources of fluoride will re-release greater amounts of fluoride. Fluoride solutions with low pH degrade the surface of glass ionomers. [40] Acidulated phosphate fluoride and stannous fluoride solutions should be avoided because they have low pH. For daily use, neutral sodium solutions are strongly recommended.

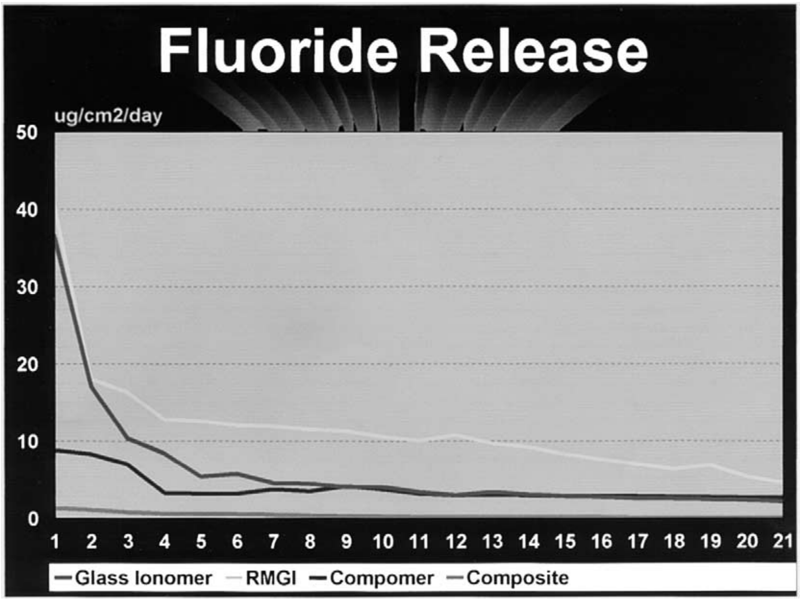

Fig. 4. Fluoride release from fluoride releasing restorative materials. Note the reduced release rates from all materials with time.

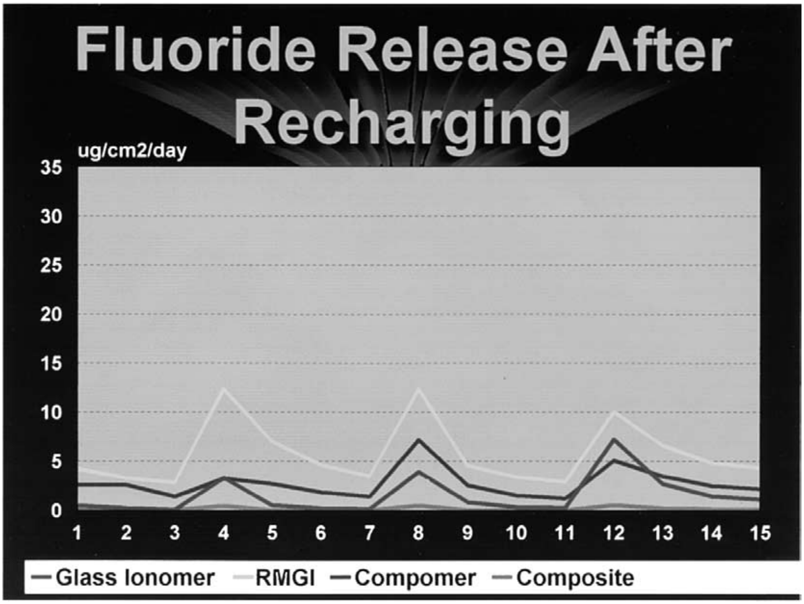

Fig. 5. Fluoride recharge occurring in four types of fluoride releasing materials with a 1-minute application of neutral sodium fluoride gel.

Restoring root caries

Resin-modified glass ionomers are indicated for high caries risk patients because they bond to tooth structure, are aesthetic, and possess long-term fluoride release that can be replenished with topical fluoride applications. Radiation, medications, and syndromes reduce salivary flow, increasing carious lesion formation, such as cervical caries, incisal caries in anterior teeth, and rampant recurrent caries around existing restorations. Typical class V carious lesions on root surfaces are difficult to restore because the gingival margin of the lesion is often subgingival. To gain access to this area, a variety of techniques have been developed (Table 2). The simplest technique places a retraction cord in the gingival sulcus. Retraction cord is packed into the sulcus to push the gingival tissue away from the gingival margin and to gain access to sound tooth structure. Although this is the easiest technique, it is often inadequate to provide proper access to the gingival margin. A second noninvasive technique for retracting the gingival margin for carious root-surface lesions is the 212 clamp. The lingual beak of this clamp is bent to allow the facial beak to displace the soft tissue and expose the gingival margin. A third, but more invasive, method of exposing the gingival margin is bone sounding and the miniflap. In this procedure, two vertical incisions are made in attached gingiva and a sulcular incision is made, connecting the two vertical incisions. If the decay ends without extending mesially or distally to the line angles, the vertical incisions are started at the line angles,

Table 2
Restorative materials used to restore Class 5 carious surfaces

Material class	Fluoride release	Adhesive	Aesthetic recommendations
Composite resin	None	Yes, with bonding agent	High; low caries risk with high aesthetic demands.
Fluoride-containing composite resin	Little	Yes, with bonding agent	High; low caries risk with high aesthetic demands.
Glass ionomer	High	Yes	Moderate; high caries risk with moderate aesthetic demands.
Resin-modified glass ionomer	High	Yes	Moderate; high caries risk with moderately high aesthetic demands.
Compomers	Moderate	Yes, with bonding agent	High; moderate caries risk with high aesthetic demands.
Amalgam	None	No	Low; low caries risk with low aesthetic demands. Most useful in posterior applications.

and the gingival papilla are not included. If the carious lesion extends around the tooth, the papilla may have to be included in the sulcular incision, and the flap will include the papilla (Fig. 6). A full-thickness sulcular incision connects the two vertical incisions. The flap is then reflected (Fig. 7), and the rubber dam is positioned (Fig. 8). The rubber dam applies pressure to the soft tissue, and bleeding virtually does not occur. If the bone sounding reveals that the carious lesion is located at the level of the bone without room for biologic width, then the bone must be removed to create space for the soft tissue attachment and the sulcus. To determine which of these retraction methods to use, it is important to determine whether the apical extent of the lesion is located 2 mm above the height of the alveolar crest.

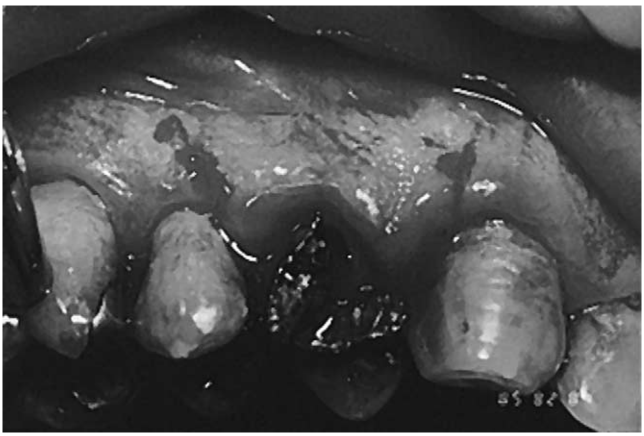

Fig. 6. Vertical incisions of a miniflap which include the papilla.

Fig. 7. Miniflap reflected allowing excellent access to the gingival margin.

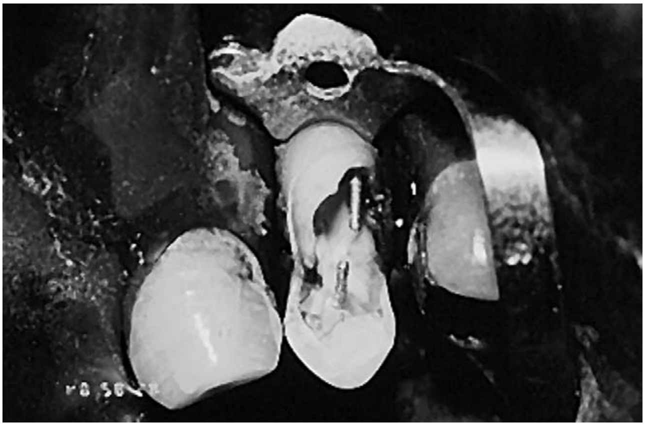

Fig. 8. Rubber dam placed over the reflected flap. Note lack of bleeding due to pressure applied by the rubber dam.

If the lesion and the restoration infringe on biologic width, inflammation will occur. Bone sounding by pushing a periodontal probe through the attached gingiva to the bone generally is used to determine the location of the restorative margin to the bone.

After the lesion is exposed and isolated with a rubber dam, a resin-modified glass ionomer may be placed. A conditioner (Fuji II LC) or a light-cured primer (Vitremer) is placed and is either rinsed off (Fuji II LC) or light cured (Vitremer). After selecting the proper shade, the resin-modified glass ionomer is mixed and inserted. A thin layer is applied (Fig. 9), cured, and then the material is inserted to fill the preparation and light cured (Fig. 10). For both resin-modified glass ionomers, light curing is essential to produce an effective bond and seal. Bonding to moist dentin is essential. When these materials are placed on dry dentin, the bond strength decreases by 50%. Finishing is completed with Sof-Lex discs. No sealer or varnish is applied to the finished restoration because it will decrease fluoride release and uptake.

If the area is a highly aesthetic one, then composite resin is the material of choice because the tooth-matching ability of this material is superior to glass ionomer (Figs. 11 and 12). For directly placed composite resin restorations, fourth-generation bonding agents are recommended. These bonding agents bond to dentin by removing the smear layer and demineralizing the dentin with an acid-etching step. Subsequent application of a hydrophilic primer allows the bonding material to penetrate the demineralized dentin and surround the exposed collagen fibrils. Moist bonding produces significantly higher bond strengths than dry bonding, [41] because moisture keeps the collagen erect, allowing the resin to flow around the collagen into the tubules and form the hybrid layer. [42] After the primer is applied, it is air-dried to remove any solvent (acetone, ethanol, or water) and reapplied

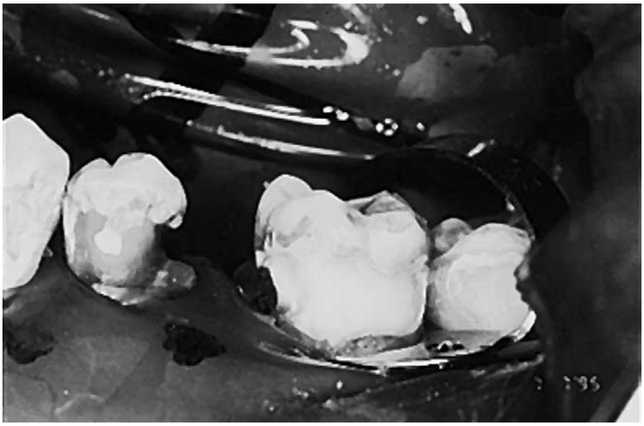

Fig. 9. Thin layer of resin modified glass ionomer is applied and cured.

Fig. 10. Completed class V resin modified glass ionomer restoration.

if a shiny surface is not apparent. Air-drying the surface is important because residual solvent inhibits polymerization of the adhesive applied subsequently. The bonding agent or adhesive is applied next and light cured. After curing the adhesive, the composite is inserted in layers no greater than 2 mm thick and polymerized.

In areas that are difficult to access, where isolation is difficult, and where aesthetics are not a concern, amalgam is the material of choice. Because amalgam is retained with mechanical retention, undercuts must be placed occlusally and gingivally. Because Tytin shrinks with time, Dispersalloy is recommended for this type of restoration. The material is mixed and condensed into the preparation and carved to proper anatomic form.

Fig. 11. Prepared tooth ready to receive the composite resin restorations.

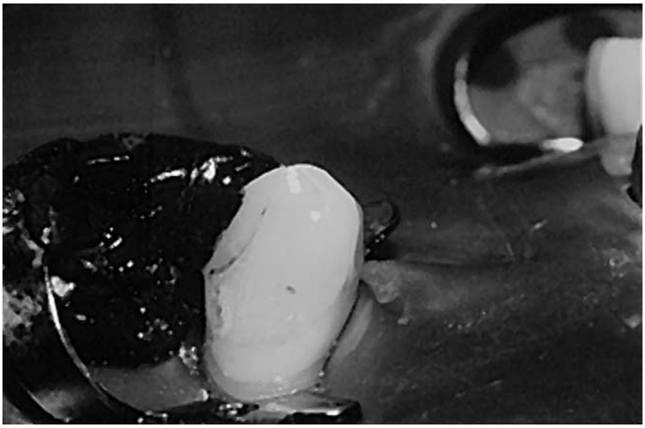

Fig. 12. Completed composite resin restoration of the preparation seen in Figure 11.

Treating caries as a disease

After the immediate restorations are placed, caries is then treated as an infectious disease. [43] To control the caries seen in the high caries risk patient, three general approaches are needed. The first is to establish the presence of *Streptococcus mutans* and then treat caries causing bacteria with an antimicrobial agent such as chlorhexidine. This antimicrobial reduces *Streptococcus mutans* counts and has been recommended for high caries risk patients. Emilson and colleagues [44,45] applied chlorhexidine gel to high-risk patients, and it reduced *Streptococcus mutans* colony-forming units and prevented recolonization [45] for more than 26 weeks. Patients should be monitored for bacteria-forming colonies and treated accordingly. The second approach for treating the high caries risk patient is with diet modification. Proper oral hygiene instructions should be given that are tailored to the individual's ability to follow the procedure. With plaque removal, diet modification is provided. Decreasing sucrose in coffee, tea, or soft drinks that are sipped all day long is critical for successfully treating these patients, because plaque-forming bacteria use fermentable carbohydrate to produce acid, which demineralizes tooth structure. Another form of constant sucrose is breath mints and chewing gum. Xylitol-containing gum should be substituted for sucrose-containing gums and mints if possible. A third part of the three-pronged defense against caries is increasing remineralization with supplemental fluoride. This fluoride can be in the form of fluoride-containing toothpaste, fluoride rinses, fluoride gels, or fluoride-releasing restorative materials. The most effective method of applying fluoride is with the nightly use of neutral sodium fluoride in a tray, because it bathes the teeth in a high concentration of fluoride. This application requires the cooperation of the patient, however, whereas fluoride-releasing materials do not require any patient compliance to be effective. Combining these therapies is more effective than any single approach. Katz [46] followed up high caries risk patients with limited salivary flow and reported that four 4-minute topical applications of a 1% sodium fluoride-1% chlorhexidine gluconate solution weekly, combined with a 1-minute nightly rinse with a 0.05% sodium fluoride-0.2% chlorhexidine solution, prevented caries and remineralized demineralized lesions. No significant side effects from rinsing with a chlorhexidine mouth rinse daily for 2 years have been reported. [47,48]

Classifying caries risk

Because teeth are fluoride reservoirs, increased tooth loss decreases the opportunity for the tooth reservoirs to be effective. Patients should be treated based on caries risk, and low caries risk patients should not be treated the same way that high caries risk patients are treated. Patients should be classified into risk groups (low, medium, and high) based on risk factors such as past caries attack (the number of decayed, missing, and filled teeth), medications or diseases that limit saliva output, and medical conditions that limit oral hygiene procedures. [49] Table 3 describes the risk category for adults and proposes appropriate treatment for those categories. Patients with the highest caries risk should be placed on combination therapies of fluoride-releasing materials, increased plaque removal regimens, and adjunctive chemical treatment.

Future developments

Carisolv [50] is a chemomechanical method for removing caries that uses sodium hypochlorite and chlorinated glutamic acid, leucin, and lysine to dissolve caries. Because the access to root caries, especially class V lesions, is

Table 3
Adult risk groups and treatments

Risk category	Conditions	Preventive options	Restorative materials
Low	No caries in 3 years, good oral hygiene, not medically comprised, no orthodontic appliances or removable appliances	Reinforce preventive program, annual recall	Sealants, composite resin, amalgam
Medium	One carious lesion in 3 years, exposed roots, fair oral hygiene, white spots or demineralization, irregular visits, removable prosthodontic or fixed orthodontic appliances, medically or physically comprised	Diet counseling, daily neutral sodium fluoride mouth rinses, topical fluoride professionally applied, fluoride toothpaste, 6-month recall	Composite resin, resin-modified glass ionomers, compomers
High	More than two carious lesions in past 3 years, past root caries, large number of exposed roots, elevated *S. mutans* count, poor oral hygiene, deep pits and fissures, frequent sugar intake, inadequate use of topical fluoride, irregular dental visits, inadequate saliva flow, physically comprised	Measure and monitor *S. mutans* counts, apply 1-week bid tray application of chlorhexidine; modify diet with dietary counseling; recommend use of xylitol mints and gum; recommend fluoride toothpaste, daily use of neutral sodium fluoride mouth rinse, and 1.1% sodium fluoride gel; 3-month recall	Resin-modified glass ionomer restorative materials, glass ionomer luting agents, core materials, and so forth

bid = twice a day.

good, this system has been advocated for its treatment. The system has been evaluated clinically, and most patients required less or no anesthesia for caries removal.

Bonding agents applied to the root surfaces prevent root caries in artificial caries solutions. [51] Lesions that developed were significantly smaller in the resin-treated teeth compared with the untreated controls. New bonding agents may include components that will prevent bacterial adhesion or limit plaque formation. Brief exposure by lasers to root surfaces reduces tooth demineralization. [52,53] When combined with topically applied fluoride, additional protection for the root surface was produced.

The future will demand the development of standardized remineralization protocols used by all clinicians to control root caries in higher-risk patients. These protocols should be developed along with specific recommendations for chemical remineralization. [54] Root-surface caries ultimately will be controlled through a combination of prevention and restoration.

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